Is saltwater intrusion occurring from the Avon River into the shallow aquifer in Christchurch, New Zealand?

Natasha Simpson[1], Irene Setiawan[2], Leanne K. Morgan[1]

[1]University of Canterbury, [2]Lincoln University

Introduction

Seawater intrusion (SI) is the landward movement of saltwater into fresh coastal aquifers. SI is a global issue intensified by climate change-induced sea-level rise. Tidal rivers are a source of saltwater that can render the adjacent shallow aquifer vulnerable to SI (Fig. 1). In this study, we investigated the potential for SI from the tidal Avon River into the adjacent unconfined aquifer in Christchurch. We add to previous work by Rutter[1] that identified temperature fluctuations with tide within a number of shallow monitoring wells near the Avon River. Our study aims to identify whether solute transport is occurring from the river into the adjacent aquifer.

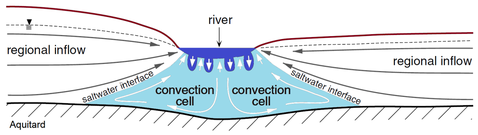

Figure 1. Salinization through riparian systems[2]

Field Sites

Figure 2. Field sites located along the Avon River, Christchurch.

Methods

- Analysis of historical groundwater level and temperature data from the Automated Piezometer (APP) Network[1] to identify tidal patterns in shallow groundwater
- Installation of groundwater conductivity, temperature, and depth (CTD) loggers into three existing shallow piezometers (Fig. 2)
- Installation of two river loggers measuring conductivity and temperature (Fig. 2)
- Preliminary geophysical surveys including Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar at Kibblewhite Reserve

Results to Date

Table 1. Summary of results for field sites

Site	Distance from river (m)	Tidal efficiency*	Water table tidal fluctuation**	Temperature fluctuation**	Specific conductance fluctuation**	Max salinity (g/L)
Kibblewhite Reserve (APP165)	50	26 %	0.30 m	0 – 0.08˚C	0 – 3 µS/cm	0.13
Collingwood St (APP192)	20	24 %	0.27 m	0.24˚C	1 – 170 µS/cm	2.73
Brooker Ave (BH-BUR-27)	60	20 %	0.23 m	0.08˚C	1 – 40 µS/cm	0.77

* Tidal efficiency is considered as groundwater fluctuation height / river tidal fluctuation height (1.14 m)
**Values displayed represent an average parameter fluctuations per tidal signal (between high and low tides)
Salinity calculated as TDS (mg/L) = K_e * SC with K_e of 0.68 from Hem[3]. Seawater salinity ~ 35 g/L, fresh water < 1 g/L.

Tidal efficiency decreases with distance up the river but tidal fluctuations are still evident. Do fluctuations of temperature and conductivity in groundwater indicate saltwater intrusion?

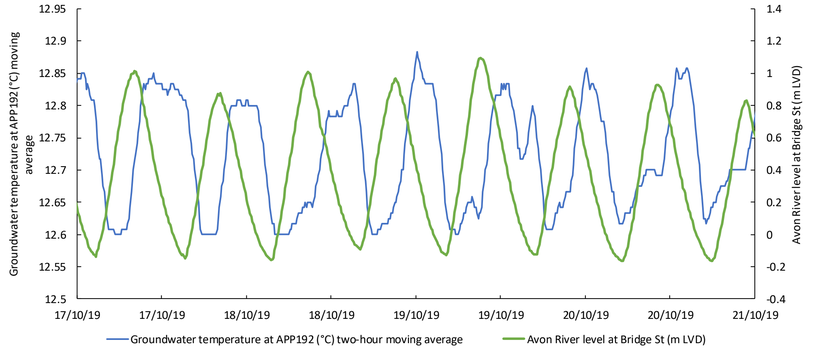

Figure 3. Groundwater temperature at APP192 fluctuating with the Avon River tidal signal.

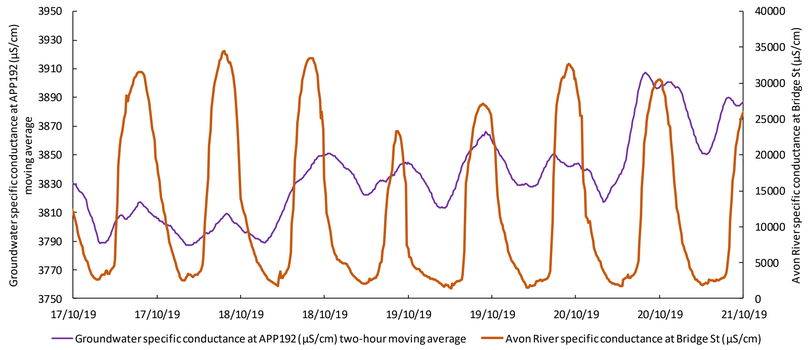

Figure 4. Groundwater specific conductance at APP192 fluctuated in phase with the Avon River specific conductance, indicative of saltwater intrusion.

Preliminary Geophysical Survey

The ERT survey was undertaken 1.5 hours after high tide over a period of 1 hour 10 minutes. The delayed start time was to capture high groundwater levels which typically occur 2 hours after high tide at this site.

Figure 5. ERT survey transect at Kibblewhite Reserve

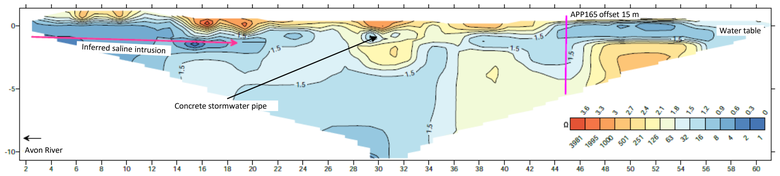

Figure 6. ERT survey results. The low-resistivity plumes indicate saltwater intrusion along a preferential flow pathway. The high-resistivity lens present at the transect mid-point is identified as a concrete stormwater pipe present on Christchurch City Council's Three Waters asset map[4]

Findings and Discussion

- CTD logger data show tidally-driven conductivity fluctuations, particularly in APP192.
- The ERT survey completed over a high tide signal at Kibblewhite Reserve showed a low-resistance plume extending into the shallow groundwater table from the Avon River side, indicative of saltwater intrusion from the Avon River into the shallow aquifer.
- Additional research can be conducted to identify other factors leading to conductivity fluctuations such as an influx of heavy metals.

Yes! Preliminary results indicate that saltwater intrusion is occurring from the Avon River into the adjacent shallow aquifer.

Acknowledgements

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References

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